

Chapter 4

Geology and Hydrogeology

4.1 Primary Issues

Protection of water resources at the site is a major project issue, since Vashon/Maury Island residents rely on wells for their water. With the applicant proposing to remove large amounts of earth from the site, changes in the water regime of the site would be inevitable. This chapter evaluates primary issues associated with the geology and hydrogeology of the property, as identified by the analysis team and by concerned citizens.

The primary issues analyzed are:

- Would mining as proposed affect recharge of the aquifer system or affect the availability of water to residents on Vashon/Maury Islands?
- Would mining affect groundwater quality?
- Would the mining activity breach an aquifer or otherwise impact adjacent groundwater wells being used by local residents?

4.2 Affected Environment

To understand how the proposed mining operation would change water regimes, one must first understand the existing geology and water regime. The water regime describes the way water enters and leaves a particular area. The following sections describe the water regime on the site and how it relates to water regimes on other lands within the Vashon/Maury Island system.

4.2.1 Information Sources

Background information for this section is contained in Appendix A, Geology and Groundwater Discipline Report. This report documents King County's independent analysis and conclusions based on site groundwater and geologic data.

Data sources include data logs from five monitoring wells, three of which are equipped with continuous-recording transducers that track static water levels (static water levels are measurements of groundwater depth taken at a particular time and place). During the review of the applicant-prepared SEPA Checklist, King County's EIS consultant team determined that these five wells were needed to (1) determine the groundwater depths, changes in depths over time, and groundwater flow direction; and (2) provide long-term groundwater monitoring stations to direct operations, should the proposed mining proceed. King County's consultant team also provided input on where wells should be located, reviewed and concurred with the locations, and observed drilling operations. King County's consultant team then used the monitoring data to conduct the independent analysis and to make conclusions about how mining would affect water regimes.

The wells will continue to track groundwater levels, thereby showing how groundwater levels change over time and/or during mining. For example, the monitoring conducted over the summer will be incorporated into the groundwater analysis for the Final EIS and, should mining continue, would be used to fine-tune final excavation limits per levels specified in the Grading Permit. Recent results for groundwater quality and groundwater level monitoring are included in Appendix E.

The 6-inch-diameter well holes range from 60 to 300 feet below the existing surface. As they were drilled, geologists took samples of the materials and mapped and described them (AESI 1999). King County's consulting team used these descriptions to assess site geology.

Similar geologic mapping and well drilling operations have occurred throughout Maury Island. Well logs from these projects were used to describe regional geology and the geology of surrounding areas. These well logs are from files at the Washington State Department of Ecology. The locations of the wells are shown in Appendix A. Logs of the Sandy Shores and Gold Beach wells come from Washington State Health Department files. It should be noted that different people using different terms wrote the water well logs, so some interpretation by the EIS team was required. The cross sections are based on the logs that appear to use consistent terminology and upon the judgment of the EIS team, based on local experience in the Puget Sound basin. Appendix A provides details regarding the AESI and other well reports.

The terms used in this EIS follow those used in the Vashon/Maury Island Water Resources Study (Carr and Associates 1983, referred to as the “Carr report”) and the Vashon/Maury Island Groundwater Management Plan (Vashon-Maury Island Groundwater Management Committee 1998). The Carr report was a general study conducted for the entire Vashon/Maury Island area and, therefore, provides good information for the vicinity but lacks the site-specific information and details that were included in the analysis for this EIS. Likewise, the Groundwater Management Plan provides a framework for managing groundwater on Vashon/Maury Islands and outlines the overall geology and groundwater regimes of the islands. The specific classifications of aquifers and related geologic features used in these two reports are useful in discussing specific groundwater sources in the vicinity of the site. Both of these previous studies are referred to in this chapter, as cited.

Terms and conditions reported on the United States Geologic Survey (USGS) geologic map of Vashon and Maury Islands (Booth 1991) were also used in this analysis. However, the USGS geologic map was a regional effort. As would be expected, variations exist between this regional mapping effort and the site-specific information collected for this EIS. The analysis presented in this chapter is based largely on the site-specific information obtained by direct sampling at the site.

4.2.2 Geology

4.2.2.1 Site Topography

The inland portion of the site is gently sloping. The steep bluffs along the shoreward edge of the site range between 200 and 300 feet above the Puget Sound shoreline. The bluff faces are covered by native vegetation except at the immediate location of the conveyer system and dock, and in places where the top layers of soil have slid off the slope, resulting in exposed soils (a process referred to as shallow sloughing). Such sloughing is a natural process that occurs on similar bluffs throughout the shorelines of Puget Sound. The toe of the bluff has been eroded by wave action.

Mining at the site has caused some obvious changes to site topography. At the eastern portion of the site, past mining removed up to 250 vertical feet of material, resulting in a large, horseshoe-shaped excavation covering about 40 acres. Other mining-related changes at the site include two unpaved roads that lead off of SW 260th Street along the northern margin of the site.

One road enters the site near the northwestern property corner and provides access to the upper portion of the site. The second road enters the site near the northeastern property corner and provides access to the lower part of the site, including the existing dock.

The materials that make up the geology of the site include topsoils and discontinuous layers of till near the surface. This is underlain by coarse sands and gravels, grading to finer sands near the bottom of the deposit. These materials have been deposited over time at the site as a series of layers. Generally, the deeper the material, the older and finer it is.

4.2.2.2 Surface Materials

Surface materials (or surface soils) are the upper and most weathered part of the soil profile (the underlying sands, gravels, and other materials on the site are referred to as subsurface materials). It follows that surface soils are the youngest materials on the site. These soils formed onsite by erosion of underlying materials and, therefore, reflect the composition of these deeper materials. Where sandy and gravelly materials are close to the surface, the soils are sandy and gravelly and are referred to as Everett series soils. Where till soils are close to the surface, the soils are rocky and mixed, and are referred to as Alderwood series soils. (See the next section for further discussion of till.)

4.2.2.3 Subsurface Materials

The site is underlain by till, sand, and gravel left by glaciers. Till is a relatively unsorted mixture of clay, sand, gravel, rocks (ranging in size from pebbles to boulders), and other materials left by glaciers.

The shallowest of these materials on the site is classified as Vashon lodgment till, and it occurs in thin pockets near the surface throughout the site. The Vashon till was deposited at the base of the Vashon age glacier that occupied the Puget Sound basin about 13,000 to 16,000 years ago. This soil was deposited beneath the moving ice. Till in the Puget Sound region is often thick (sometimes occurring in a layer 100 feet or deeper) and sometimes is tightly bound like concrete. Because of this, till often has low permeability, meaning that water does not flow through it very easily. However, at this site, the till layer is less than 20 feet deep and more typically around 5 feet deep. In addition, in its thinner occurrences, it lacks the concrete-like structure found elsewhere. Therefore, the till at this site does not form a major barrier for water.

Underneath these thin pockets of till is a deep layer of sand and gravel referred to as Vashon Advance outwash deposits. These are the materials that would be mined. The advance outwash sand and gravel were deposited by meltwater streams and rivers that flowed off of the glacial ice as it advanced into Puget Sound from Canada approximately 16,000 years ago. These materials grade from coarser sand and gravel near the top of the deposit to finer sands near the base.

The materials that would be mined continue from near the surface down to various depths. The differences in depth are typical in the Puget Sound region, because the materials were deposited over rolling hills and valleys rather than over a flat surface (such as a lakebed, for example). That is why sand and gravel materials in this region are typically not found in flat, orderly layers. The sands and gravels at the Lone Star site appear to have been deposited in a historic basin situated between hills. The Lone Star site is situated near the center of this basin, which allowed a thick sequence of sand and gravel to accumulate and is why it has been used as a mining site.

The advance outwash soils that make up the majority of the materials on the site exhibit a range of permeabilities (permeability is a measure of how easily water flows down through a material). Overall, the materials are highly permeable (water flows easily through them), especially near the surface. This is because materials near the surface are coarse gravels and sands with abundant gaps that allow water to flow downward (i.e., they have higher permeability). Water flows less freely (i.e., slower) in the lower portions of the deposit, where finer materials are packed closer together, allowing less space for water to flow through.

While the materials that would be mined vary in permeability, none are so impervious as to form a water barrier or to slow water down to the point that it becomes an aquifer (such barriers are called aquitards). Small, isolated pockets of water-saturated materials are expected to occur due to differing material size and density, but none of these “pockets” would contain sufficient water to be considered an aquifer. (See Section 4.2.4.3, Deeper Perched Water.)

The oldest and deepest materials on the site are believed to be the Olympia Formation. The Olympia Formation was material deposited by and in streams and lakes during non-glacial periods. These landscapes resembled the current landscape of Puget Sound. In general, these materials, as encountered on the Lone Star site,

consisted of fine sand with traces of wood fragments. This material is below the materials that would be mined.

4.2.3 Surface Water

Besides the obvious presence of Puget Sound and the associated tidelands, no streams or other surface waters enter the site. Therefore, rainfall and groundwater are the only potential sources of surface water at the site.

Small amounts of water exit the site via springs along the beach. These springs are below the area that would be mined. These springs exist where the top of the aquifer has been exposed by past wave erosion.

Because the site is underlain with highly permeable sand and gravel, most rainfall percolates down into the underlying groundwater system, rather than collecting in wetlands or streams. No evidence of creeks or seasonal water bodies is present on the uplands or within the pit area on the site. During heavy rains, water collects and runs off the compacted soils on the existing roads, and drainage channels are present along the edges of roads. These storm flows follow the compacted drainage channels until reaching undisturbed areas or exposed sands of the existing pit area, where they then enter the ground.

4.2.4 Groundwater

4.2.4.1 Overview of Basic Terms and Concepts Related to Groundwater

Groundwater is any water present beneath the surface. It occurs in open spaces in soil, sand, gravel, and other sediments, and is a major element of the hydrologic cycle. The hydrologic cycle begins with precipitation (typically rain on this site), which infiltrates relatively quickly into the ground at the Lone Star site.

Once water enters the ground, it will flow downward through porous and permeable materials, such as gravel and sand, until reaching a barrier (called an aquitard), such as a layer of compact till, thick clays, fine silts or water pooled up behind such layers.

When a significant amount of water remains in place over time and completely saturates the ground materials, it forms an aquifer. These aquifers can occur at different depths or can be otherwise

dispersed throughout the three-dimensional area beneath the surface.

Based on the analysis conducted for this EIS, three main groundwater bodies have been identified in the vicinity of the site: (1) an interflow network; (2) the principal aquifer, and (3) the deep aquifer. The following sections describes these groundwater bodies.

4.2.4.2 Interflow Groundwater

Interflow groundwater is the water below the ground surface that is not part of an aquifer. In the Puget Sound basin, interflow typically develops near the surface within low-permeability soils. Often, this lower permeability layer is a till. The interflow typically moves laterally (sideways) along the top of the till rather than vertically (downward) through the till. Interflow often recharges streams and creeks in the Puget Sound basin. The interflow also serves as a reservoir for deeper recharge through the till or other material that comprises the aquitard.

Based on direct field observations made by the King County consulting team, and on the team's analysis of data collected by AESI, no significant interflow network exists on the site. In other words, water is not entering the ground and then immediately flowing laterally (sideways) off the site. Instead, the rainfall continues to move downward to recharge the aquifer below the site's surface or else evaporates or is taken up by plants.

The only exception is that laterally flowing water was detected within some of the till layers that occur near the surface. As mentioned earlier, these till areas are relatively less permeable than the underlying sands and gravels, but, nonetheless, do allow water to flow through them. In addition, since the till layers occur in patches, the laterally flowing water eventually reaches more permeable sand and gravel, at which point it starts to again move downward toward the water table. Also, "drains" of higher permeability soils are present within the till that allow the near-surface interflow to drain into the sands and gravels and, eventually, to recharge the principal aquifer.

4.2.4.3 Deeper Perched Water

At some places on the site, layers of more densely packed sands and gravels slow the downward movements of water to the point that isolated "pockets" of water form. Such pockets were found at two of the wells on the site. The depths of these pockets were

45 feet (well OBW-6) and 200 feet (well OBW-7). Because these layers of more dense materials are not connected, the pockets of water are also not connected, and water eventually either drains slowly through these materials or “pours” off the edges of the deposit, where sand and gravel occur. This is similar to the situation previously described within the till layer, where, in places, water is slowed and may move laterally, only to eventually drain through “holes” in the material or by reaching the permeable sands and gravels.

4.2.4.4 *Aquifers*

An aquifer is a relatively large and stable underground water body formed by water-saturated materials above some sort of barrier. In previous studies conducted on Vashon/Maury Island, researchers described a primary aquifer, which resides in the sands and gravels of the Vashon advance outwash, and a deep aquifer, which resides in the much lower, pre-Vashon sediments. This is the typical system that occurs throughout the Puget Sound region, since the Vashon outwash deposits typically are underlain by silts and clays that restrict water flow (these deposits are known as the Quarternary Transition Beds). This base serves to separate groundwater into distinct aquifers. The upper aquifer within the advance sands and gravels is the principal aquifer. The lower aquifer in the pre-Vashon sediments beneath the lacustrine sediments is the deep aquifer.

At the project site, however, it appears that this separation between the primary aquifer and the deep aquifer is not so distinct. The silts and clays are absent beneath the Lone Star site and vicinity. For the purposes of EIS analysis, the aquifer at the Lone Star site can be thought of as one continuous system. Other pre-Vashon aquitards do exist in the vicinity of the site, where the deep aquifer is clearly separated from the primary aquifer.

At the Lone Star site, the materials that would be mined are located above the primary aquifer.

4.2.4.5 *Static Water Levels*

For mining, one of the most important considerations is where the top of the aquifer is located. This elevation is often referred to as the water table, and measurements of the water table taken from wells are called the static water level.

Static water levels are not fixed, but rather change in response to climatic change and, sometimes, human influences. Human

influences can be removal of large amounts of water through wells, or breaching of aquifers through major land excavations, or changes in the recharge regime by intercepting rainwater and diverting it away from the aquifer recharge zones. Static water levels also change in response to changes in the barometric pressure. They rise during low pressure and fall during high pressure. Minor variations may even occur due to influences of the moon and related tides.

Even with these variations, the overall water level measured at any one particular point on the site is relatively stable. Water that enters these sands and gravels travels slowly. At the Lone Star site, it is expected that rainwater takes up to a year to slowly percolate down through the sands and gravels until finally hitting the water table. Water is moving downward in a slow, steady flow by the time it reaches the water table and enters the aquifer. Therefore, despite variable precipitation such as rainstorms at the surface, the water table at the site is expected to fluctuate in the order of only a few feet over the course of a year, with most fluctuation being less than one foot. Ongoing monitoring conducted over the summer will provide more information regarding this natural fluctuation.

Based on the wells established for this EIS and on previous wells, static water levels at the Lone Star site measure between around 90 feet above sea level at the highest point to around 20 feet above sea level at the lowest. The levels generally follow the topography, with the higher levels located upslope and inland, closer to the primary recharge zones, and the lower levels located near the shoreline at the groundwater discharge area. Figure 4-1 presents the groundwater contours found at the site.

4.2.4.6 Aquifer Recharge

Water that enters the site (and that does not leave via evaporation or by being taken up by plants) eventually reaches the underlying aquifer, thereby contributing to the recharge of this aquifer. The recharge occurs initially within the Vashon outwash sediments. From these sediments, some of the water continues deeper into the pre-Vashon sediments (referred to as the “deep aquifer” by Carr and Associates [1983]), while the remaining water flows directly from the outwash deposits to Puget Sound.

Looking at the site within the context of Maury Island, recharge generally occurs in a radial pattern centered on the highest and central-most portions of the island, with all discharge eventually going into Puget Sound (except for that which is removed via

wells). The interface area, where the aquifer discharges into Puget Sound, is expected to occur underground along the margins of the island. This is a typical recharge regime for an island.

This “radial discharge” pattern is illustrated on the project site by the relatively steep gradient of the water table, with the static water level being near 90 feet above sea level toward the top of the site, grading down to near 20 feet at the shoreline area of the site. The water table at the site is grading down to meet the waters of Puget Sound. The fact that one of the wells located near the shoreline fluctuates in response to the tides indicates that this site is near where the fresh and saltwater bodies meet, and, therefore, near where the freshwater aquifer is discharging into Puget Sound. The springs on the shoreline below the site further indicate that this site is a discharge point for groundwater.

The speed of discharge from the freshwater aquifer to Puget Sound is greatly affected by the materials through which groundwater flows and the gradient of the top of the water table. In some areas, the groundwater may flow relatively rapidly, and in others, more slowly. At the Lone Star site, due to the relatively deep deposit of highly permeable sand and gravel and its location in a subsurface basin, this area is a point of relatively rapid discharge.

4.2.4.7 Adjacent Wells

Several wells are located on Maury Island. Well water is the only significant source of water on the island. The four major well systems addressed in this EIS are (1) Gold Beach wells, (2) Sandy Shores well, (3) the Iliad well, and (4) the Dockton Water Company well system (three sources).

The Iliad well, located about 0.5 mile northwest of the Lone Star site, is the only well that may be downgradient, meaning that some groundwater beneath the Lone Star site may eventually flow toward this well and contribute to its recharge. Nevertheless, this connection is relatively minor. This is due to the well’s distance (half a mile) and its location further inland on the island. As stated earlier, the overall trend of groundwater is to flow away from the central portions of the island toward Puget Sound.

At the Sandy Shores well, the static water level is reported to be near 61 feet above sea level. Given its location, it is cross-gradient, or roughly at the same level, as the water table at the Lone Star site. At Gold Beach, which maintains two wells located side by side, the static water level is approximately 29 feet above sea level, which again corresponds to groundwater levels at a

similar inland distance at the Lone Star site. Thus, the Gold Beach wells are cross-gradient and perhaps on a different limb of a groundwater mound than the Lone Star site.

The Dockton Water Company has two springs where water is collected in addition to the Sandy Shores well. The first set of springs is in the center of a swale across the street from the Dockton Park. The water level in these springs is estimated to be about 30 feet above sea level. This corresponds with the elevation of the static water level in the similar position on the Lone Star site relative to the beach. Because the water table is higher at places between the Lone Star site and the Dockton Park springs, a groundwater divide separates the Dockton Park springs from the Lone Star site. The divide is located somewhere south of the Lone Star site. This further illustrates the radial flow of water out from the center of the island.

The second spring field used by the Dockton Water Company is the Hake Springs. These springs are located at about 100 feet above sea level. This elevation is higher than the elevation of the water on the Lone Star site. Hence, Hake Springs is clearly upgradient of the Lone Star site, meaning that water at the Lone Star site does not flow to Hake Springs.

Groundwater flowing beneath the site has been determined to discharge directly into Puget Sound. The site appears to be a discharge zone for water from the principal aquifer on this part of Maury Island. Some of the water beneath the site likely contributes to deeper aquifers in the immediate vicinity of the site.

4.3 Impacts

4.3.1 Would mining as proposed affect recharge of the aquifer system or affect the availability of water to residents on Vashon/Maury Islands?

4.3.1.1 *Proposed Action*

Aquifer Recharge. A primary concern regarding the Proposed Action is that mining would limit aquifer recharge and decrease the amount of drinking water available to residents on Maury Island. However, with appropriate drainage and recharge designs (as described in the mitigation section of this chapter), mining would not reduce the amount of water that this site currently contributes

to the aquifer and, therefore, would have no effect on local water supplies.

Previous and ongoing studies indicate that impacts on drinking water would not occur for four additional reasons. First, as stated earlier, the site does not contribute to a lateral interflow network that directs water offsite.

Second, the site is located in a discharge area of the aquifer, rather than a recharge area. This is reflected in the sharp, downward “slope” of the groundwater found at the site, with depths being near 90 feet above sea level toward the top of the site, grading down to near 20 feet at the shoreline area of the site. This reflects the typical offshore flow of groundwater on an island system, and also reduces concerns regarding recharge to the portions of the aquifer used for drinking water.

Third, although mining would change the timing of rainwater reaching the aquifer, effects on the groundwater table would be localized and would not affect the amount of water available to residents. Mining at the site would change the timing and the path that rainwater takes from the surface of the site to the underlying aquifer. The timing of recharge would change through a major decrease in the time it takes rainwater falling on the site to reach the aquifer. Water now takes up to a year to percolate through the deepest deposits of sand and gravel at the site. As mining reduces the depth of these deposits, this lag time would be reduced.

The magnitude of this reduction in lag time would depend on the depth of material left between the surface and the groundwater. This depth would be similar to existing depths near the site perimeter, but would become shallower toward the central portions of the mine, where, at final grade, a minimum 15 feet of materials would separate the floor of the mine and the water table. At these minimum depths, water may take as little as 20 days to move from the surface to the underlying aquifer. At other locations, such as near the site perimeter, a greater depth would be maintained and recharge rates would be more similar to the existing situation.

This decrease in recharge time would cause variations in the quantity of water entering the aquifer at any given time. This is because the existing deep sands and gravels act to “measure” the downward flow of water into a relatively stable flow as it reaches the groundwater table. With the depth of sands and gravels reduced, this measuring effect would be reduced. During rainy periods, recharge would be relatively high, and during dry periods, recharge would be relatively slow.

The water table is expected to respond to this variation by showing localized increases and decreases in the water table immediately below the site. The magnitude of such swings is estimated to be in the range of a few feet. Currently, the groundwater table varies, on average, about 1 foot. Following mining, localized variations may be up to about 5 feet. Because of this, the final elevations of the mine floor must be adjusted to accommodate potential maximum groundwater levels.

These variations would be localized at the site and would not affect the amount of water available to residents. This is because the amount of water entering the groundwater table would not change. Locally, a steeper groundwater gradient would occur.

The fourth factor that further supports the conclusion that the local water resource would not be reduced is that the amount of rainwater that enters the ground would actually increase considerably at locations being actively mined and reclaimed. This is because vegetation, particularly forest, intercepts much of the rainwater. In cleared areas, up to 10 times as much rainwater may enter the ground to recharge underlying aquifers compared to a forested area. This effect would occur within the 20-acre active mining cells and recently reclaimed areas. Eventually, vegetation on reclaimed areas would again take up much of the rainwater, thereby making this increased recharge a temporary effect that would occur only during and immediately following active operation of the mine.

In conclusion, mining would not affect the local drinking water supply because (1) appropriate drainage and recharge designs would be used, (2) the site does not contribute to lateral interflow, (3) the site is located within a groundwater discharge area rather than a recharge area, (4) the amount of water reaching the aquifer would not be reduced, and (5) during operation and early periods of reclamation, recharge would actually increase because of vegetation removal.

Water Use. To control dust, the operator may use up to 10,000 gallons of water during dry periods. The water would be brought into the site from offsite sources. Daily water use on Vashon and Maury Island is currently about 1,200,000 gallons per day (Vashon-Maury Island Groundwater Management Committee 1998). Therefore, at maximum use, the site would increase water consumption on the Island by 0.8 percent. However, over the course of a year, much less water is expected to be required on average. Conservation measures to reduce water consumption, as

well as measures to disperse the source of water, would serve to effectively reduce any strain on water resources.

4.3.1.2 *Alternative 1*

The impact of Alternative 1 is the same as the Proposed Action, with no decrease in available water to Maury Island residents. The effect of increased recharge through vegetation removal would occur over a longer period because the site would remain open for a longer period, thereby leaving exposed areas of rapid infiltration available over a longer time.

Potentially less water would be used under Alternative 1 for dust control.

4.3.1.3 *Alternative 2*

Same as the Proposed Action and Alternative 1, with no significant effect on the amount of drinking water available on the Island. As with Alternative 1, potentially less water would be required for dust control.

4.3.1.4 *No-Action*

The No-Action Alternative would not affect available drinking water for the same reasons provided under the Proposed Action. Dust control water needs would be negligible.

4.3.2 *Would mining affect groundwater quality?*

4.3.2.1 *Proposed Action*

The primary concern related to groundwater quality is potential introduction of sediments or contaminants into the groundwater table. Concerns regarding arsenic and other contaminants related to the ASARCO smelter are addressed in Chapter 10, Environmental Health and Safety.

The potential for impacts from fuel spills is small due to the relatively small amount of machinery that would be required to operate the mine. At full operation, up to three loaders and four bulldozers would be in operation. The applicant has not specified fueling procedures, but typically a fuel truck supplies fuel at a designated location. As a good management practice, such designated fueling areas are lined to contain possible fuel spills.

Such a measure has been included in Section 4.4.2, Additional Measures for Consideration to Further Reduce Impacts.

Impacts resulting from sedimentation are not expected for several reasons. First, the sands and gravels at the site that would separate the groundwater table from the surface would serve to effectively filter sediments or other contaminants. The sands that are present at the base of the proposed mining operation generally meet the specification for water treatment sands for stormwater management facilities (King County Storm Water Design Manual 1998). King County requires a minimum of 2 feet of such sands to filter stormwater. At the site, at least 15 feet of materials would be present to serve as a filter to groundwater. This will protect the aquifer from contaminants adsorbed onto sediment particles. No source for contaminants that would be dissolved in stormwater is expected during the mining operation.

Finally, as stated earlier, the site is at a discharge point, rather than a recharge point, so that the trend of water movement is toward Puget Sound and away from any well sites.

Considered collectively, these factors illustrate that the project would not significantly affect groundwater quality.

4.3.2.2 Alternatives 1 and 2

As with the Proposed Action, Alternatives 1 and 2 would result in no significant adverse impacts on groundwater quality.

4.3.2.3 No-Action

Same as Proposed Action, with no significant adverse impacts on groundwater quality.

4.3.3 Would the mining activity breach an aquifer or otherwise impact adjacent groundwater wells being used by local residents?

4.3.3.1 Proposed Action

A major issue that must be addressed with any mining operation is the potential for breaching of an aquifer. Breaching occurs when excavations actually cut into an aquifer, causing water to flow out. This situation occurred in a sand and gravel pit near Monroe in

Snohomish County in 1993, where an aquifer was breached and drained a significant amount of water, impacting nearby wells.

However, at the Lone Star site, the materials that would be mined are located above the aquifer. As described in Section 4.4, Mitigation Measures, a 15-foot separation would be maintained between the bottom of the mine floor and the groundwater table. Therefore, there is no potential to breach an aquifer. As mentioned earlier in this chapter, small, isolated pockets of water are expected to occur within the material that would be mined. However, these isolated pockets do not contain sufficient water to be considered an aquifer in themselves.

4.3.3.2 Alternatives 1 and 2

No aquifers would be breached under Alternatives 1 and 2, for the same reasons identified under the Proposed Action.

4.3.3.3 No-Action

No aquifers would be breached under No-Action, for the same reasons identified under the Proposed Action.

4.4 Mitigation Measures

4.4.1 Measures Already Proposed by the Applicant or Required by Regulation

- To prevent impacts from sedimentation, the walls of the mining pit would slope toward the mine floor and away from Puget Sound to reduce runoff into the Sound. A retention/infiltration pond would be constructed at the bottom of the mine site. This pond would be sized according to DNR and King County standards for a 25-year, 24-hour storm event. Additional sedimentation ponds would be constructed to reduce the potential for siltation to limit the infiltration capacity of the retention/infiltration pond.
- Rock check dams would be established at minimum intervals of 75 feet where gradients exceed 10 percent in the benches or channelized runoff paths to reduce velocities and sediment transport impacts. Runoff paths would be directed into the retention/infiltration pond.
- The site would be excavated to an elevation of 50 to 70 feet National Geodetic Vertical Datum (NGVD), or 43.6 to

63.6 feet mean lower low water (MLLW). A minimum 15-foot buffer would be maintained between the bottom of the pit floor and the measured static groundwater level. While unlikely to occur, action plans for groundwater seepages into the mining area would be included in the mining plan, including immediate notification of King County and technical experts.

- To determine static groundwater levels, the applicant will measure the static water levels of the primary aquifer in monitoring wells, according to the terms outlined in the required Groundwater Monitoring Plan. Any natural fluctuations in the static levels of the aquifer would be identified as mining progresses, and the depth of mining would be altered as necessary to maintain the 15-foot buffer.
- Groundwater levels would be monitored on a quarterly basis over a 5-year period following approval of the revised Grading Permit and Surface Mining Reclamation Permit. After 5 years, monitoring may be reduced to annual measurements if no impacts to water levels have been identified. Monitoring would cease during the reclamation phase.

4.4.2 Additional Measures for Consideration to Further Reduce Impacts

- To minimize changes in the rate and path of recharge waters on the site, the applicant's proposed drainage plan could be modified to more accurately mimic the existing infiltration pattern. The standard benches proposed by the applicant could be constructed with a reverse slope back into the hill to encourage infiltration in the upper portions of the mine, rather than directing all water down to a single detention/infiltration pond.
- A series of temporary water collection ponds could be prepared on upper slopes as part of each mining phase. Again, this is preferable to a single pond at the bottom of the mine. Most areas under active mining would require no surface water detention or storage since water would readily enter the exposed sand and gravels, rather than washing over the surface and collecting in pools. However, where roads are present, where compaction has occurred, or near areas of stockpiled tills or other less permeable materials, appropriate drainage and upslope infiltration ponds should be constructed.

- During reclamation, each completed cell should, to the extent possible, allow water to infiltrate within the cell, rather than being directed off to some central portion of the site.
- To prevent possible intrusion of the mine into the water table, groundwater levels should be monitored as each cell approaches final grade. Adjustments of final elevations should be made to accommodate potential increases in groundwater levels.
- A designated fueling area could be established to contain possible fuel spills. The area could be lined with fabric under gravel, could be constructed of concrete with appropriate spill capture reservoirs, or could involve the placement of absorbent pads. Such measures would effectively eliminate significant risks to groundwater contamination from fuels.
- Finally, to minimize the potential drain on local water supplies, the applicant should utilize conservation measures for water consumption, including use of misting and related techniques. Such conservation measures should be specified in a water conservation plan to be prepared and approved by King County as a condition of permit approval.

4.5 Cumulative Impacts

Since the project would not affect aquifer recharge or water quality, no cumulative impacts would occur in these areas. Use of water for dust control would be an additive water use on the Island.

4.6 Significant Unavoidable Adverse Impacts

Mining would eventually reduce the deep layer of sand and gravel deposits at the site. This would in turn reduce the time it takes water to reach the water table and would likely result in greater peaks and lows in recharge rates over the course of a year. This impact is not considered significant, however, since the actual amount of recharge (the key element of concern) would not be significantly affected. The amount of water that reaches the site as rain would not change as a result of mining activities. Removal of vegetation would temporarily increase the amount of water that enters the water table, but this amount is not particularly significant in terms of the overall aquifer. The additional measures presented in Section 4.4.2 would serve to further reduce impacts and address public concerns.

4.7 Citations

AESI. See "Associated Earth Sciences, Inc."

Associated Earth Sciences, Inc. 1999. Draft addendum geology and groundwater report. Maury Island Pit, King County, Washington. March 3. Prepared for Lone Star Northwest, Inc.

Booth, D.B. 1991. Geologic map of Vashon and Maury Island, King County, Washington, with text to accompany map MF2161. U.S. Department of the Interior, U.S. Geological Survey, Map Distribution Center. Denver, CO.

Carr and Associates. 1983. Vashon/Maury Island water resources study. December 1. Prepared for King County Department of Planning and Community Development.

Vashon-Maury Island Groundwater Management Committee. 1998. Final Vashon-Maury Island groundwater management plan. December.

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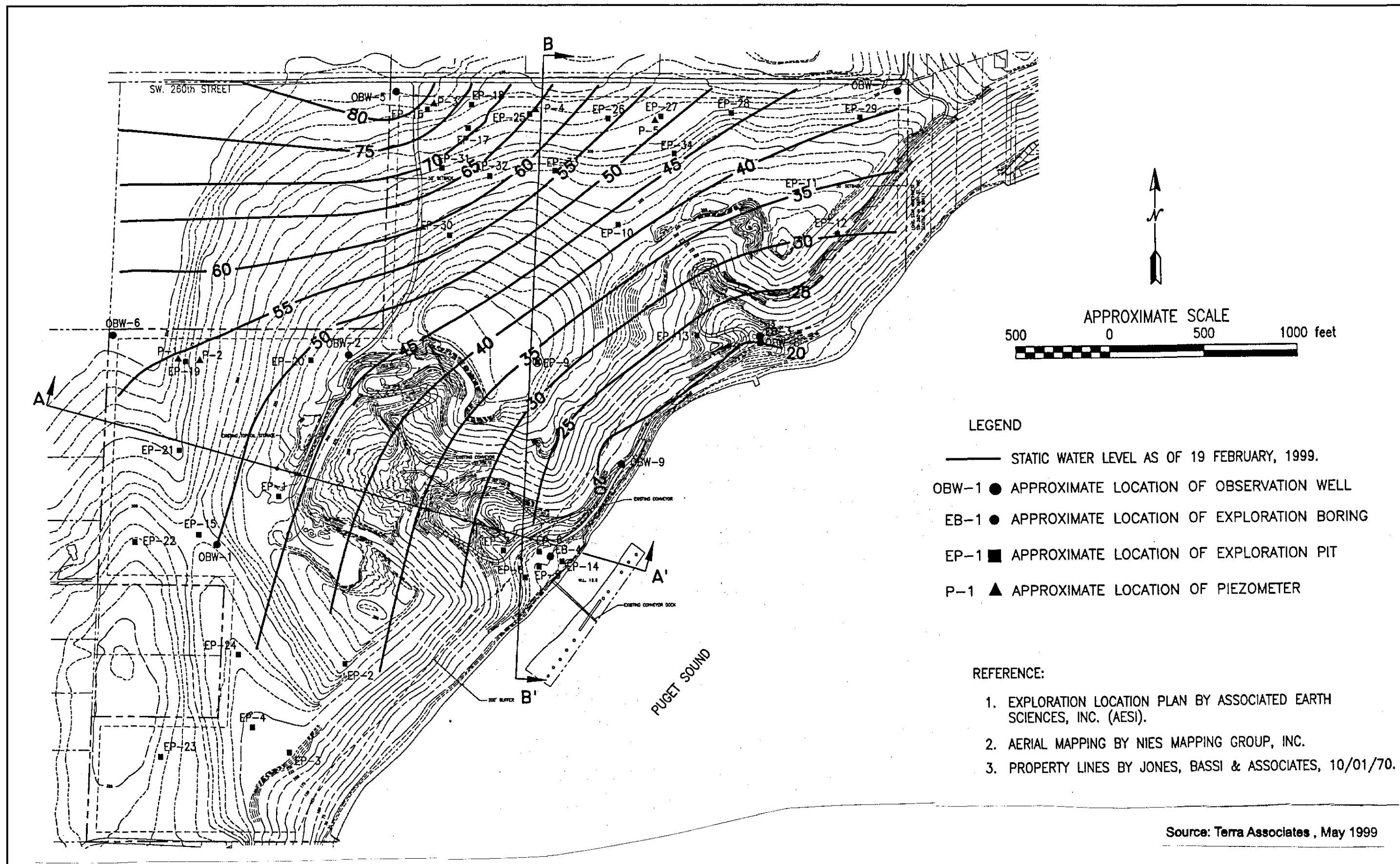


Figure 4-1. Groundwater Contours